FutureDrive

Volume 3, Number 1 DOE/Industry Competitions Advancing Automotive Technology Spring 1997

TECHNOLOGY FEATURE

Driving the Future Takes Teamwork

David Holloway, newly elected President of the Society of Automotive Engineers International (SAE), is convinced that tomorrow's clean, energy-efficient cars will emerge from today's worldwide partnerships between automotive companies, government, and universities. He explains why this teamwork is crucial: "By harnessing the intellectual power and creative energy of today's engineering students, we'll get there a lot faster. The brain-power of our students is really a resource that must not be wasted."

Recently, Holloway embarked on a tour from Washington, D.C., to Detroit, Michigan. What's so remarkable about this tour? He drove a winning Saturn hybrid-electric vehicle (HEV) fueled by ethanol and electricity. A University of Maryland mechanical engineering professor, Holloway was accompanied by 4 of the 80 engineering students instrumental in the vehicle's conversion: Ian Evans, Fred Householder, George Martin, and Mayette San Juan. Christine Ervin, DOE Assistant Secretary, Energy Efficiency and Renewable Energy (EERE) at the time, and Tom Gross, DOE Deputy Assistant Secretary, Office of Transportation Technologies (OTT), kicked off the tour on February 18 in Washington. (See photo.) The group stopped in Baltimore, Philadelphia, and Pittsburgh. Their final destination: the SAE International Congress and Exposition, held on February 24–27 in Detroit, where Holloway was installed as President of the 71,000-member professional organization.

The 1991 Saturn hybrid had won first place in the 1994 Hybrid Electric Vehicle (HEV) Challenge. This competition was sponsored by DOE, General Motors Corp., and SAE, as well as Ford Motor Co. and Chrysler Corp. The vehicle's innovative design is very similar to the Prius, which Toyota intends to manufacture as the first commercial HEV. (See Winter 1996–97 *FutureDrive*, "DOE Report," p. 2.) The ethanol—E85 (85% ethanol, 15% gasoline)—fueling the hybrid is produced from corn grown in Maryland. A sophisticated system of computer controls automatically switches on a battery-powered electric motor when the vehicle needs additional power for passing or other sudden acceleration. During deceleration, or when the vehicle is running only on ethanol, the electric motor becomes a generator and automatically recharges the batteries.

The impressive result: A one-liter engine that delivers the performance of a standard three-liter power plant at about half the fuel consumption, and without the need to stop and recharge the batteries.

Holloway has been a successful faculty advisor in almost every vehicle competition sponsored by DOE, including all three HEV Challenges, Sunrayce, the Methanol Marathon, the NGV Challenge, and the FutureCar Challenge. His role in these competitions, combined with his demonstration of innovative vehicle technologies, contributed significantly to his election as SAE President. He plans to make an international vehicle competition the centerpiece of his term as the organization's President.

For more information, refer to SAE's Web site (http://www.sae.org).

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Volume 3, Number 1, Spring 1997

Purpose
To inform past, present, and potential sponsors, participants, organizers, volunteers, and others interested in DOE-sponsored vehicle competitions about the plans for and results from the competitions.

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Impressive Technology Improvements Emerge from Propane Vehicle Challenge

The 1997 Propane Vehicle Challenge offers a superb example of how engineering competitions improve alternative-fuel vehicle technology and provide educational and personal growth for engineers entering the job market. Liquefied petroleum gas (LPG) has been a satisfactory (though relatively unnoticed) transportation fuel for a long time. In most ways, it already competes well with gasoline. But propane has no large fuels industry anxious to accelerate its acceptance in a growing transportation market. Consequently, there had been no real push for more sophisticated propane vehicle technology—until college and university teams took up the challenge. Their efforts in this year's competition resulted in some impressive improvements:

- *Conformal propane fuel tanks.* The teams pushed tank designs to new levels to meet the required range (650 km or 400 miles). Long cylindrical tanks of different diameters are joined by conical sections to give sufficient ground clearance under the vehicle. Even bolder are the rectangular tanks made by joining truncated oblong cylinder shapes into large tanks that have oval cross-sections. One design has a deep notch in the middle to clear the frame rail. Each configuration was approved in the design phase and inspected thoroughly after fabrication and on the vehicle. These new tanks show that LPG fuel packaging can be comparable to or better than gasoline vehicles.
- *Advanced fuel-injection systems.* This year's proliferation of liquid phase fuel-injection systems showed that propane technology continues to close the gap with gasoline. By using many stock gasoline components, propane-powered vehicles can match gasoline technology in power density, air/fuel ratio control, and cost. One popular system was designed and built by a small company that currently employs one of last year's team captains. The company wants to hire additional graduates from this year's competition. Surely, this is technology transfer at its best!
- *Lower emissions.* Advanced catalyst configurations and formulations are demonstrating significantly lower emissions from the propane vehicles than from the gasoline-powered stock vehicles. Because cold-start emissions can be greatly reduced, and there are no evaporative or running loss emissions with propane, the emissions profiles of these advanced propane vehicles are likely to set new low-emissions records in engineering design competitions. (See article on p. 3.)
- *Improved driveability and overall performance levels.* The teams have changed the vehicle fuel system and engine configuration to overcome traditional drawbacks of gaseous fuels (power loss) and propane-powered vehicles (poor hot start performance).

These advances are enabling propane-fueled vehicles to meet or exceed the performance and consumer acceptability of conventional vehicles. A complete report on the '97 competition results will appear in the next *FutureDrive*.

Shelley Launey
Manager of Vehicle Competitions
DOE Office of Transportation Technologies

Propane's Low-Pollution Potential Evaluated through Improved Emissions Measurements

'97 PROPANE VEHICLE CHALLENGE

In the second annual Propane Vehicle Challenge (PVC), held in Austin, Texas, on May 14–19, 17 teams of student engineers competed with Chrysler minivans and Dodge Dakota pickup trucks converted to propane fuel. The Challenge's eight judging events included evaluations of exhaust emissions as well as fuel economy, range, efficiency, and engineering.

During last year's PVC—the first ever held—emissions testing measured total hydrocarbons, non-methane hydrocarbons, oxides of nitrogen (NO_x), and carbon monoxide (CO). This year, stringent emissions evaluations supplemented these tests and gave a more complete picture of propane's potential as a low-polluting fuel. Southwest Research Institute (SwRI), with its state-of-the-art emissions facility, provided accurate and credible emissions profiles for each PVC participant. Like last year, testers conducted a modal analysis. This year, however, they measured aldehydes and ketones in the vehicles' exhaust streams and estimated non-methane organic gas (NMOG) applying the reactivity correction factor (RAF). The RAF adjustment factor is important because the latest emissions standards aim to restrict the more "reactive" constituents of auto exhaust.

The more meaningful emissions measurements taken at this year's Challenge will provide useful data to help researchers improve propane and other alternative-fueled vehicle technologies.

In the timed modal analysis, samples of exhaust were taken before and after the catalysts. The samples helped researchers to calculate the efficiency of the catalyst and better determine engine operating conditions in which pollutants are created. Emissions measurements were taken throughout the standard Federal Test Procedure driving schedule and included key engine conditions such as startup, acceleration, and deceleration.

A more discriminating analysis of exhaust emissions was done by measuring the toxic compounds—formaldehyde and acetaldehyde—in the aldehydes. From these measurements, NMOG content was estimated and used in tandem with the RAF adjustment factor. This more complete data will help researchers quantify the relative cleanliness of propane as a vehicle fuel. A lower RAF value implies less participation in the photochemical reactions that produce smog. Importantly, RAFs for propane are lower than those for other fuels. California Air Resources Board standard propane has an RAF of 0.5, compared with an RAF of 0.94 for "California Phase 2 reformulated gasoline," or RFG. (See accompanying graph.)

The more meaningful emissions measurements taken at this year's Challenge will provide useful data to help researchers improve propane and other alternative-fueled vehicle technologies. More detailed results from the '97 PVC will be published in the upcoming issue of *FutureDrive*.

Contributors: Kevin Whitney
Southwest Research Institute
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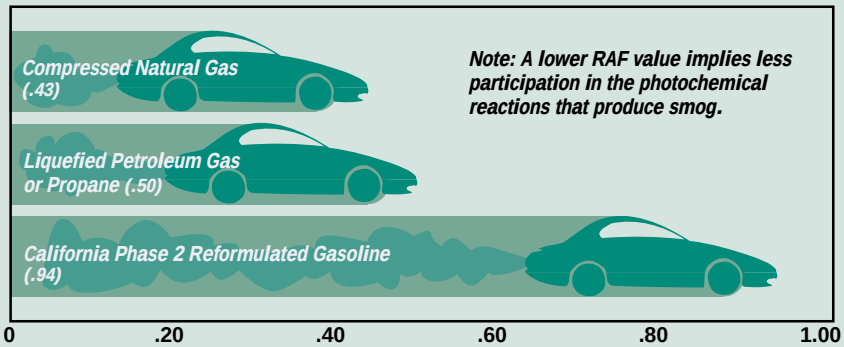
RAF Values for Three Alternative Fuels



Source: California Air Resources Board (CARB)

Detroit Edison Stands at Forefront of EV Commercialization

Detroit Edison continues to gain momentum toward establishing market applications for electric vehicles (EVs) and making them commercially viable through partnerships with its automotive and automotive supplier customers. Most recently, Edison purchased 50 of Chevrolet's new S-series EVs and has committed to the purchase of up to 50 Ford Ranger electric pickup trucks for use in its company fleet. The utility has provided the auto industry with over-the-road evaluations for other types of electric vehicles during nearly 20 years of research and almost 900,000 miles of operation.

"The information gathered at past FutureCar and HEV Challenges has proved invaluable. This is the type of information that helps Detroit Edison prepare to support electric vehicles as they are mass-produced for commercial fleets."

Detroit Edison maintains an active role in the national "EV-Ready" market launch program. In this program, Detroit is part of a 10-city EV informational project aimed at helping communities develop policies and deploy the infrastructure necessary to support the introduction of EVs in the city. Edison is committed to helping

communities develop EV implementation plans that address four key areas: public policy support framework, charging systems, public education and awareness, and a well-maintained support system.

The utility promotes educational efforts to enhance the understanding and use of EVs through sponsorships such as the Department of Energy's (DOE) FutureCar Challenges (1996–97) and Hybrid Electric Vehicle (HEV) Challenges (1993–95), as well as past Society of Automotive Engineers Micro Electric Vehicle Challenges. Edison's long-standing participation with electric vehicles serves to demonstrate to potential buyers that electric vehicles are a viable choice for nonpolluting vehicles.

Detroit Edison has been involved with the FutureCar Challenge and HEV Challenge since their inception. "This is the fifth year we've had the honor of participating in these special events that serve to advance electric vehicle technology with future engineers and scientists. The competitions allow us a unique opportunity to test equipment for all prototypes," says John Olsen, Program Manager of Electric Vehicles at the utility.

"The information gathered at past FutureCar and HEV Challenges has proved invaluable. Through the testing of charging systems during the event, we identified potential problems with multiple vehicles charging at the same time. This is the type of information that helps Detroit Edison prepare to support electric vehicles as they are mass-produced for commercial fleets," adds Olsen.

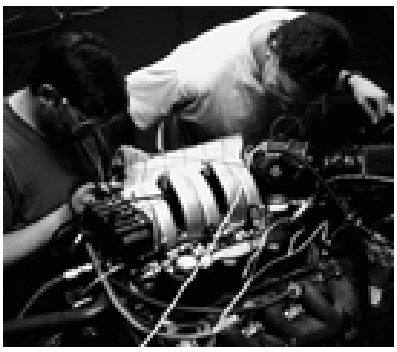
Detroit Edison is also a key stakeholder in the Detroit-Toronto Clean Cities Corridor, the largest international corridor ever to be designated under the Clean Cities program. The corridor is known as the "Center for Automotive Excellence" for North America, due to the large concentration of automotive production in the area. For more information about Detroit Edison's EV program, contact John Olsen (phone: 313/235-8912).

Jocelyn Lincoln
Marketing Communications Manager
Detroit Edison

Small School Puts Up a Big Fight in the Propane Vehicle Challenge

With an enrollment of 2,500 students, Cedarville College (near Dayton, Ohio) might not be a familiar name to many people. Don't let the small size of this school fool you: It has a big impact. Cedarville has seven student design teams, each focusing on a different competition: the Propane Vehicle Challenge, Micro Baja Trucks, Mini Baja, Aerodesign, Autonomous Ground Robot, Supermileage, and Solar Splash. This year, the propane team co-leaders, Scott Hoadley and Cindy McFadden, prepared a young team consisting of three upperclassmen, fifteen sophomores, and five freshmen for the Propane Vehicle Challenge, held May 14–19. The men and women of this team certainly gave their competitors a run for their money in the competition.

Cedarville, a private, comprehensive college with a Christian liberal arts tradition, has been participating in alternative fuel vehicle competitions since 1993. Being part of a design team is primarily an extracurricular activity for participating students. The small size of the school demands that the team make the most efficient use of its human and financial resources. Chuck Allport, the propane vehicle team advisor, explains the program's philosophy: "The real product for us is not the



technology, it's the student. Participating in this competition gives them valuable insight into how industry really works. That's an important concept."

To help the learning process, the school developed a close relationship with the Dayton Society of Automotive Engineers International (SAE). The program establishes practicing engineers as mentors. "Like the other schools involved in the Challenge, we're trying to turn out engineers that can handle real problems, not just hypothetical situations," says Allport.

When discussing the team's preparation for the competition, Allport states, "In the real world, it's performance, cost, and schedule that count. It's no different here." Most teams learn to address technical issues, handle deadlines, and function as a team while working on the vehicles, but the Cedarville propane team outdid themselves in two particular situations. The first one involved a negotiating problem rather than a technical challenge. A vendor doubled the price of a key component before delivery. Suddenly, the students needed to raise an additional $4,000. The team members went looking for new sponsors and within *two days* had the money they needed for the part.

The second situation was much more complex, but no less successful. The key to a good propane conversion is use of a conformal fuel tank. That meant designing a tank that would use space more efficiently in the vehicles and then demonstrating that the new tank would meet federal safety requirements for pressure tanks. To accomplish this task, the team collaborated with two competitors, the University of Alberta and GMI Engineering and Management Institute. Together, the three teams worked with Sleegers Engineering and Thiokol. These cooperative efforts resulted in a piece of technical work with commercial value. Allport claims, "Not only was the work valuable to the competition, it was a step in the commercial evolution of propane tanks."

This team has shown real ingenuity and can be proud of what they have accomplished. "We really appreciate the competition opportunities that the Department of Energy provides," reflects team leader Scott Hoadley. "We learn a lot, but it's also very gratifying to contribute to a technology that makes a real difference." Before the competition even began, Cedarville was already a winning team.

For more information about the teams and vehicles, contact Chuck Allport (phone: 937/766-7681; fax: 937/766-7661).

Ann Rogers
Communication Coordinator/Analyst
Argonne National Laboratory

Fourth Annual EV Grand Prix Features New Events

Eighteen high school teams from across the Mid-Atlantic region tested the limits of the electric vehicles (EVs) they designed and built in the fourth annual EV Grand Prix on April 24–26. Virginia Power sponsored and hosted the competition at Richmond International Raceway. The Science Museum of Virginia, also a sponsor, will manage the event in 1998.

"Electric vehicles represent a cutting-edge technology that has arrived. This form of transportation holds the promise of creating a better environment and enhancing energy efficiency," comments James T. Earwood, Jr., Virginia Power's Vice President-Bulk Power Delivery. "The students participating in the EV Grand Prix received valuable, first-hand experience with a technology that will play a major role in their lives during the 21st Century."

Students competed in EVs converted from gasoline-powered vehicles. Since the students' vehicles must meet stringent technical and safety requirements, all EVs underwent rigorous technical inspections prior to the competition.

The following new events gave students a chance to demonstrate their creativity and knowledge of electric vehicles, as well as explore the limits of EV performance and engineering:

- *The Road Course.* Competitors drove EVs through a slalom course marked by safety cones that tested the cars' maneuverability.
- *EV Video.* Student teams showed 60-second videos produced at their schools. Targeted at the general public, the videos promoted EVs. This event aimed to broaden the EV program's appeal to students interested in art, music, and communications.
- *Trouble-Shooting Competition.* Students demonstrated their skills in this timed event by diagnosing an EV for problems seeded by event organizers. Students were graded on their proficiency in identifying problems and suggesting solutions.

"Electric vehicles represent a cutting-edge technology that has arrived. This form of transportation holds the promise of creating a better environment and enhancing energy efficiency."

Other EV Grand Prix events that determined overall competition winners focused on the vehicles' range and acceleration. In addition, a question-and-answer competition tested the students' knowledge of EV technology.

Virginia Power has a long-standing commitment both to educational programs and advancing the EV industry. The company's EV fleet is one of the largest in the United States, with 43 EVs performing routine business functions every day.

For more information, contact Cindy Dickerson, Virginia Power (804/775-5624).

EV Grand Prix Competing Schools and Sponsoring Utilities

Schools	Sponsors
Manassas Park High School – Team #1, Manassas Park, VA Manassas Park High School – Team #2, Manassas Park, VA	Northern Virginia Electric Cooperative/Old Dominion Electric Cooperative
Phelps Vocational High School, Washington, DC Suitland High School, District Heights, MD	Potomac Electric Power Co.
Richmond Technical Center – Team #1, Richmond, VA Richmond Technical Center – Team #2, Richmond, VA Hermitage Technical Center, Richmond, VA Gloucester High School, Gloucester, VA Norfolk Technical Vocational Center, Norfolk, VA Chesapeake Center for Science & Technology, Chesapeake, VA George Marshall High School – Student Auto Sales, Falls Church, VA Fairfax High School, Fairfax, VA Lake Braddock High School, Burke, VA* Central Shenandoah Valley Regional Governor's School, Fishersville, VA	Virginia Power
Northampton County East-Team #1, Conway, NC Northampton County East-Team #2, Conway, NC	North Carolina Power

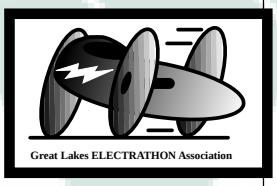
*Denotes a new school for the 1997 competition.

APS Electrics
The APS Electrics competition was held March 7–9 in Phoenix, Arizona. More than 80 professional and student teams, of which about 40 were high school teams, came from 17 states and Canada to compete. In the High School Student Electric Competition, Gloucester High School (Gloucester, VA) took first place; North Hampton High School (Conway, NC) placed second; and Palo Verde High School (Tucson, AZ) came in third. In the ABB University Spec division, a team from Indiana University/Purdue University (Indianapolis, IN) had the winning car, with second place awarded to Bowling Green University (Bowling Green, OH). Third place went to Ohio State University (Columbus, OH). The APS Electrics is sponsored by Arizona Public Service (APS) and is organized by Electric Vehicle Technology Competitions (EVTC).

1997 Chicago Junior Solar Sprint
On May 3, the eighth annual Chicago Junior Solar Sprint was held at Case Corp. in Hinsdale, Ill., southwest of Chicago. The competition allows seventh- and eighth-grade Chicago-area science students to build and race solar-powered model cars. At least 15 schools entered this year, with some schools submitting more than one model. The Sprint encourages middle-school students to apply aerodynamics and engineering skills to achieve low vehicle weight, friction, and rolling resistance, as well as high overall performance efficiency. Sponsors of the Junior Solar Sprint are DOE, Argonne National Laboratory, and Case Corp. Additional corporate sponsors are being solicited for the 1998 competition. If interested in serving as a sponsor, contact Christine McGhee at Argonne National Laboratory (phone: 630/252-8677).

NESEA American Tour de Sol
The route of this year's NESEA American Tour de Sol (ATdS), held May 17–24, started in Waterbury, Connecticut, and ran through five New England states. The 1997 electric vehicle championship—the ninth such—attracted a large field of entries. As of early April, about 45 teams had entered, including 28 student teams. Electric and hybrid vehicles competed in the categories of production, commuter, solar commuter, U.S. Department of Energy (DOE) hybrid, and one-person. DOE presented cash prizes to the winning student vehicles in the hybrid and commuter categories, as well as daily efficiency awards. The American Tour de Sol is organized by the Northeast Sustainable Energy Association (NESEA) and sponsored by DOE, Goodyear Tire and Rubber Co., several New England utility companies, and New England state agencies and corporations.

Michigan High School Electrathon Competition
The fourth annual Michigan High School Electrathon Competition (MHSEC) features two oval track races held at the Michigan Ideal Speedway, south of Lansing, on May 24 and June 7. The competition consists of a one-hour event around a closed track. The vehicle that travels the farthest wins. Typically, other smaller events are also held. The Great Lakes Electrathon Association (GLEA) assists the competing high schools in raising funds, and designing, constructing, testing, and racing electric vehicles restricted to 64 pounds (and 36 volts) of deep-cycle, lead-acid batteries. In 1997, 21 schools entered 32 cars in the competition. Schools from Michigan, Iowa, Nebraska, North Carolina, Wisconsin, and Ohio were invited to participate. Faculty and students have praised the competition in providing "hands-on" experience and motivating students to put into practice what they've learned in math, automotive, physics, and English classes. DOE and Grand Valley State University are sponsors of this year's competition.



FutureCar Challenge
The 1997 FutureCar Challenge will be held June 3–11 in Warren, Michigan, and Washington, D.C., with stops in Akron, Ohio, and Warrendale, Pennsylvania. The Challenge requires competing university students to take donated mid-size American sedans and improve their fuel economy. 1997 is the second year of a two-year test to determine whether the cars' fuel economy can be tripled—without sacrificing performance, safety, or affordability. The teams apply creative engineering either to a Chevrolet Lumina, Dodge Intrepid, or Ford Taurus; they can use an alternative power train and/or fuel, replace outer body panels, and improve overall aerodynamics. In 1996, 10 of the 12 vehicles entered were hybrid-electric vehicles. This year's Challenge will include a new event to judge the cost and manufacturability of the vehicle technologies and an over-the-road endurance event. Primary sponsors of the FutureCar Challenge are DOE and the United States Council for Automotive Research (USCAR), a research venture formed by Chrysler Corp., Ford Motor Co., and General Motors Corp.

Sunrayce 97
Participants in Sunrayce 97, a biennial solar car competition scheduled for June 19–28, will set out from Indianapolis, Indiana, and finish in Colorado Springs, Colorado. Interest was so great that Sunrayce organizers whittled 60 college and university teams down to 40 entrants by holding two qualifying weekends this spring. After "scrutineering" for roadworthiness, the vehicles completing the most laps won a space in the June competition. Sunrayce is sponsored by General Motors Corp., Electronic Data Systems, and DOE.

Contributors: Richard Stein and Paul Zellar

Argonne Staff Elected as SAE Officers

Three Center for Transportation Research staff members at Argonne National Laboratory were elected to serve on several Society of Automotive Engineers International (SAE) governing bodies.

Bob Larsen, Technology Engineering Section Leader, Energy Systems Division, was elected to the SAE International Board of Directors for a three-year term starting in 1998.

Bob Larsen

Frank Stodolsky, Mechanical Engineer, has been named Vice Chair of SAE's Advanced Power Plant Committee for a one-year term. Typically, Vice Chair becomes Chair at the end of the term.

Scott Sluder, Staff Engineer, was elected as Secretary of SAE's Chicago Section for a one-year term.

Argonne Paper Presented at Emissions Workshop

Mike Duoba, Staff Engineer, Center for Transportation Research, Argonne National Laboratory, presented a paper on "Challenges for the Vehicle Tester in Characterizing Hybrid-Electric Vehicles" at the Coordinating Research Council's 7th On-Road Vehicle Emissions Workshop held April 9-11 in San Diego, CA. For a copy of the paper, contact Mike Duoba (phone: 630/252-6398).

Cruise through *FutureDrive* on the Web

You can now access *FutureDrive* through Argonne's Web site (http://www.es.anl.gov/htmls/information.html#anchor9788124). We will continue to add issues so that *FutureDrive* is just a "click" away when you need information on DOE-sponsored student competitions.

Wanted: Survey Comments

We'd like your comments about where you showcase your competition vehicles and who views them. If you have participated in any of the DOE-sponsored competitions, please take a moment to fill out the *FutureDrive* survey (http://www.es.anl.gov/htmls/futuredrive.form.html).

1997 EVENTS

June 3–11

FutureCar Challenge
Mid-sized Vehicle Conversions
Warren, Michigan

- *Contact:*
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June 19–28

Sunrayce 97
Biennial Intercollegiate
Solar Race across America
Route: Indianapolis, Indiana,
to Colorado Springs, Colorado

- *Contact:*
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  8040 Ortonville Road, Suite A
  Clarkston, Michigan 48348
  Phone: (800) 606-8881
  Fax: (810) 620-1547
  E-mail: headqtr@sunrayce.gmr.com
  URL: http://www.sunrayce.com

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